ocean explorer
oceanexplorer.noaa.gov

Mountains in the Sea Exploration

Fishy Deep-sea Designs!

Focus

Adaptations of fishes living in the mesopelagic and bathypelagic zones of the deep ocean

Grade Level

7 - 9

Focus Questions

How do the characteristics of seawater at 200 meters differ from those at 1000 meters? How might fishes living between 200 meters and 1000 meters of water differ from those living at depths greater than 1000 meters?

Learning Objectives

Students will learn about the physical location of deep water habitats along the Hudson Shelf Valley and in Hudson Canyon.

Students will learn the basic characteristics of the mesopelagic and bathypelagic zones with regard to depth, temperature, pressure, light level and food availability.

Students will understand how fish living in the mesopelagic and bathypelagic zones have adapted to survive in each respective habitat.

Students will learn that many fishes are bioluminescent.

Students will learn why fishes bioluminescence.

Students will learn about a variety of deepwater fishes through independent research.

Students will predict where scientists will find certain species of fish living along the Hudson Shelf Valley and in Hudson Canyon in the upcoming expedition.

Materials

- ❒ Overhead of map of Hudson Shelf Valley and Hudson Canyon (http://woodshole.er.usgs.gov/project-pages/newyork/ or http://pubs.usgs.gov/factsheet/fs114-99/fs114-99.html
- ❒ Student Worksheet, included in this lesson – 1 per student
- ❒ Internet access for students
- ❒ Optional: the 28-minute video "Night Life: Creatures of the Deep" created by the New England Aquarium and Bermuda Underwater Exploration Institute (to order call the New England Aquarium at 617-973-5288 or access their website at wowfilms@neaq.org)
- ❒ Optional: the 26-minute video "Marine Bioluminescence: Secret Lights in the Sea" produced by Harbor Branch Oceanographic Marine Science Educational Series (to order call 772-465-2400 x692 for telephone orders, email at giftstore@hboi.edu or via their website http://www.hboi.edu/index_04.html
- ❒ Representative images of mesopelagic and bathypelagic fishes (can be accessed from multiple sources listed in Resources section)
- ❒ Bucket (with handle) of water
- ❒ Ice
- ❒ Thermometer

Teaching Time
One hour for introduction (two hours if videos are included)
One week for student independent research

Seating Arrangement
Individually

Maximum Number of Students
36

Key Words
Photic
Aphotic
Epipelagic zone
Mesopelagic zone
Bathypelagic zone
Twilight zone
Midnight zone
Bioluminescence
Counterillumination

Background Information
The ocean is divided into three zones based on depth. The upper 200 meters of the ocean is termed the photic zone. This zone is penetrated by sunlight and plants thrive. Food is relatively abundant. This region is also called the epipelagic zone and this term refers to the upper layer of the open ocean or "top pelagic" zone in the ocean.

The Mesopelagic Zone
Immediately below the epipelagic zone lies the mesopelagic zone and this zone extends from 200 meters to 1000 meters in depth. This zone is also called the middle pelagic zone. In the mesopelagic zone, dim light still exists but not at high enough levels to support plant growth. This zone has yet another name and has been coined the "twilight" zone which refers to the dissipation of light with increasing depth. At the lower depths of the twilight zone, light penetration becomes minimal and darkness abounds. Since the sunlight available to the depths of the mesopelagic zone is not sufficient enough to support plant growth, the availability of food, as compared to the epipelagic zone, is much reduced. Only about 20% of the food produced in the epipelagic zone makes its way to underlying waters of the mesopelagic zone.

It is in the mesopelagic zone that a transition between the warm surface waters of the epipelagic and the constant cold temperatures of the bathypelagic zones (see below) occurs. This transition in temperature is called a thermocline. At 200 meters, the temperature averages roughly 23 degrees Celsius and then declines linearly with depth to about 4 degrees Celsius at 1000 meters. Animals that migrate through the mesopelagic zone experience quite a bit of change in temperature, while animals that tend to stay at the same depths experience far fewer fluctuations.

Since pressure increases with depth (one atmosphere per 10 meters or 14.6 pounds per square inch per 10 meters), organisms living in the mesopelagic zone are under a quite a bit of pressure! The pressure at 200 meters is equivalent to 21 atmospheres or 307 pounds per square inch and at 1000 meters is equivalent to 101 atmospheres or 1475 pound per square inch.

Fishes of the Mesopelagic Zone
Many midwater fishes have light organs, or photophores, that produce light. The biological production of light is called bioluminescence. Bioluminescence has evolved in many different species and this suggests its importance to survival in the deep sea. There are several reasons why an organism may produce light. Some of these strategies are listed below, with an example of an organism that uses that strategy.

Counterillumination or "To Hide": Many animals that move up and down in the twilight zone have light producing organs on their ventral surfaces. They are able to increase the light level of their ventrally-located lights as they move into shallower, light-richer waters and dim them as they descend into deeper waters. In this manner, they become

somewhat invisible to predators swimming above or below them. A fish using counterillumination would have a ventral surface that blends in with the lighter waters above when viewed from a predator from below. This is very similar to countershading (animals with lighter ventral surfaces and darker backs, or dorsal surfaces) but uses light to achieve the same effect. Shining tubeshoulders and bristlemouths both have ventrally-located lights!

Attracting a Mate: Many organisms have species-specific light patterns and in some, specific to a certain sex. In a dark environment, this is a great way to get a date! Anglerfish and lantern fish both are thought to produce light to attract a mate.

Attracting Prey: Some organisms have lighted body parts that they use to attract prey. Gulper eels have a light at the end of their tail. It is thought that this animal might use the light to attract prey to its humongous mouth.

Escape Tactic: Some organisms will use light to temporarily distract or divert predators. Some animals will shoot out "clouds" of light. The goal is for the light to confuse or distract a predator, while the "un-lighted" animal attempts to escape.

The use of photophores for counterillumination is a characteristic, in particular, that characterizes mesopelagic fishes. Therefore, if you observe a fish with photophores on its ventral surface, the fish is very likely to be a vertical migratory fish and uses counterillumination as a survival strategy.

Most mesopelagic fishes are quite small; food is scare and the limited resources available do not support large body sizes. Bristlemouths and lanternfish are the most abundant in this zone. Since food is scare, many midwater fishes have large mouths relative to their body size, unhingeable jaws that can be opened wide to swallow prey, and large teeth. If a rare meal swims by, a hungry midwater fish does not want to miss an opportunity to dine!

In the twilight zone, there are numerous fishes that are black or red. At depth, these fishes are not visible. The black animals absorb all colors of light available and the red animals appear black as well; there is no red light to reflect and their bodies absorb all other available wavelengths of light. Thus red and black animals predominate. Since the color blue penetrates best in water, there simply are not that many blue animals in the midwater regions of the ocean; their entire bodies would reflect the blue light and they would be highly visible to predators.

Fishes in the midwater zone can typically be grouped into two distinct categories; those that swim up to the epipelagic zone at night (vertical migrators) and those that remain at particular depths within the mesopelagic zone. Midwater fishes that make vertical migrations are typically black or silver, have large eyes to capture available light, a large mouth, photophores and small body size. They also tend to have well-developed swim bladders, muscles and bones; all structures that aid in migration. Fishes that do not migrate tend to be black, red or silver, have large eyes, and have large mouths, photophores and small body size. They tend to lack a swim bladder, however, and they have weak bones and flabby muscles.

Bathypelagic Zone

Below depths of 1000 meters lies a world of perpetual darkness. The depths below 1000 meters comprise the bathypelagic or "deep pelagic" zone. Due to its constant darkness, this zone is also called the midnight zone. Only about 5% of the food produced in the epipelagic zone makes it way down to the bathypelagic zone. Food is a scarce commodity in the midnight zone.

The temperature in the bathypelagic zone, unlike that of the mesopelagic zone, is constant. The temperature in this zone never fluctuates far from a chilling 4 degrees Celsius. The pressure in the bathypelagic zone is extreme and at depths of 4,000 meters, reaches over 5850 pounds per

square inch! Though quite a harsh environment, the bathypelagic zone comprises the single largest habitat on Earth.

Fishes of the Bathypelagic Zone

In the bathypelagic zone, bioluminescence is as prevalent as in the mesopelagic zone. However, in the complete darkness of the bathypelagic zone, there is no need for countershading and bioluminescence is not used for this purpose. Bathypelagic fishes tend to have fewer photophores than mesopelagic fishes and the photophores tend to be on the head and sides of the fishes in bathypelagic fishes whereas mesopelagic fishes often have photophores on their ventral surfaces.

Fishes of the midnight zone usually have no need for large, sensitive eyes and the eyes of these fishes are often absent or reduced. Since food is so scarce, energy conservation is the name of the game! Most of the fishes are sluggish or tend to stay in one place. They have watery, flabby muscles, weak skeletons, no scales and poorly developed systems (nervous, respiratory and digestive). Almost all of the bathypelagic fishes lack a swimbladder. Most bathypelagic fishes have huge mouths, are small and have black bodies.

INSERT MEL #

Learning Procedure

1. Introduce students to the Hudson Shelf Valley and Hudson Canyon by showing them the overhead of the region.
2. Show students how the oceans have been divided into three zones (epipelagic, mesopelagic and bathypelagic) based on depth. Draw a diagram on the board or use an overhead.
3. Ask students what they think the temperature, pressure, light level and food availability in the mesopelagic and bathypelagic zones might be.
4. Describe the temperature, pressure, light level and food availability in the mesopelagic and bathypelagic zones to students.
5. Use a bucket of water to demonstrate pressure. Ask a student to lie down on his/her back at the front of the classroom. Ask the student to breathe in and out. Now gently place a bucket of water on the student's lung area. Hold onto the handle of the bucket to provide support. Ask the student to breathe and to tell the class if it was more or less difficult to inhale with a bucket of water sitting on top of their chest. Ask the entire class how it might feel to breathe with 50, 100 and 1000 buckets of water sitting on top of their lungs.
6. Fill the bucket with ice.
7. Use the bucket of ice water to convey temperature. Have a student come to the front of the class and submerge their hand in the ice water. Ask them how it feels and whether they would like to take a bath in water just as cold.
8. Take a temperature reading of the ice water using a thermometer and convey reading to the class. Relate temperature reading to temperature in mesopelagic and bathypelagic zones.
9. Ask students to describe the fishes they think would live in the mesopelagic and bathypelagic zones.
10. Describe the characteristics of mesopelagic and bathypelagic fishes and record the characteristics on the board.
11. Give each student a Student Worksheet and provide approximately 20 minutes for students to complete the worksheet.
12. Tell students that they should closely observe the structure of the fishes on their worksheets and hypothesize whether each fish would be found in the mesopelagic or bathypelagic zone. Students should explain their hypothesis in the allotted space beside each fish.
13. Discuss the worksheet with students.
14. Show students representative images of fishes from both habitats. (Hatchetfish and lanternfish are good examples from the mesopelagic zone; gulper eels, deep sea anglerfish and deep sea bristlemouths are good examples

from the bathypelagic zone.)

15. If you choose to show one or both videos, show videos to students.
16. Provide students with the list of fishes from the mesopelagic and bathypelagic zone below. Allow them to select one fish and research the habitat requirements of the fish. Students should include the following in their report: a picture of the fish, the size of the fish, the depth(s) where the fish can be found, the general habitat requirements of the fish and special adaptations for survival. Also require that students include the genus and species of the fish they research and describe; many of the fishes listed below include several different species that will differ in habitat (i.e., some anglerfishes are found in the mesopelagic zone while others are found in the bathypelagic zone).

Anglerfish
Bristlemouth
Lanternfish
Hatchet fish
Gulper eel
Viperfish
Fangtooth
Dragonfish
Barracudina
Longnose lancetfish
Sabertooth fish

Note: Descriptions of some of these animals can be found on the Monterey Bay Aquarium's website http://www.mbayaq.org/efc/living_species/. Although this site provides distribution of animals in the Pacific, students can access great photographs and some good, basic information. The Monterey Bay Canyon has been studied extensively and may serve as a valuable model when students are trying to guess where scientists may find certain fish living in Hudson Canyon.

The BRIDGE Connection

Go to the BRIDGE website at http://www.vims.edu/bridge/ Under the Navigation side bar click on Human Activities to learn more about the technology used to study deep sea environments.

The "ME" Connection

If the bathypelagic zone of the ocean represents over 80% of all habitats on Earth, why might it be important to study this habitat? How might discoveries in this deep sea habitat affect your life someday?

Connections to Other Subjects

Art

Using art materials, create a canyon habitat. Place fishes at the proper depths within the habitat. Note: This builds on the evaluation tool listed below.

Mathematics

One atmosphere is equivalent to 14.7 pounds per square inch. At the surface of the ocean, one atmosphere of pressure exists due to the atmosphere above the water. Pressure in the ocean then increases one atmosphere with every increase in 10 meters of depth. How many pounds per square inch of pressure would exist at 200 meters? At 1000 meters?

Evaluation

Using art materials (construction paper, aluminum foil, glow-in-the dark paint, etc.), have students create a three-dimensional model, to scale, of the fish they researched.

Extensions

Have students visit the http://oceanexplorer.noaa.gov website to find out more about the New England Seamount Expedition.

Resources

Websites for student research:
http://www.mbayaq.org/efc/living_species/
http://www.mbari.org/
http://www.biolum.org

http://www.bioscience-explained.org/EN1.1/features.html
http://www.pbs.org/wgbh/nova/abyss/
http://oceanlink.island.net/oinfo/deepsea/deepsea.html
http://people.whitman.edu
http://www.seasky.org/monsters
http://www.divediscover.whoi.edu
http://www.nationalgeographic.com
http://www.marine.whoi.edu/ships/alvin/alvin.htm
http://www.ocean.udel.edu/deepsea
http://www.pbs.org/wgbh/nova/abyss/life/extremes.html
http://www.whoi.edu/WHOI/VideoGallery/vent.html

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science

- Structure and function in living systems
- Populations and ecosystems

Content Standard D: Earth and Space Science

- Structure of the Earth system

For More Information

Paula Keener-Chavis, National Education Coordinator/Marine Biologist
NOAA Office of Exploration
2234 South Hobson Avenue
Charleston, SC 29405-2413
843.740.1338
843.740.1329 (fax)
paula.keener-chavis@noaa.gov

Acknowledgements

This lesson plan was produced by Stacia Fletcher, South Carolina Aquarium, Charleston, SC for the National Oceanic and Atmospheric Administration.

Student Handout

In which zone, the mesopelagic or bathypelagic, do you think you would find the following fishes? Use your knowledge of both zones and the structure of each fish to formulate your hypothesis. Explain why you chose the mesopelagic or bathypelagic zone for each fish in the space provided to the right.

Fish name: Lantern fish

Mesopelagic or bathypelagic? _____
Please explain your choice below.

Fish name: Gulper eel

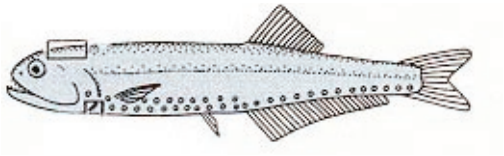
Mesopelagic or bathypelagic? _____
Please explain your choice below.

Fish name: Bristlemouth (species #1)

Mesopelagic or bathypelagic? _____
Please explain your choice below.

Fish name: Bristlemouth (species #2)

Mesopelagic or bathypelagic? _____
Please explain your choice below.



Graphics from *Marine Biology*. Castro, Peter and Michael E. Huber. 1992. Mosby-Year Book, Inc.

Student Handout

Teacher Answer Key

In which zone, the mesopelagic or bathypelagic, do you think you would find the following fishes? Use your knowledge of both zones and the structure of each fish to formulate your hypothesis. Explain why you chose the mesopelagic or bathypelagic zone for each fish in the space provided to the right.

Fish name: Lantern fish

Mesopelagic or bathypelagic? _____
Please explain your choice below.

Large eye, abundant photophores on belly

Fish name: Gulper eel

Mesopelagic or bathypelagic? _____
Please explain your choice below.

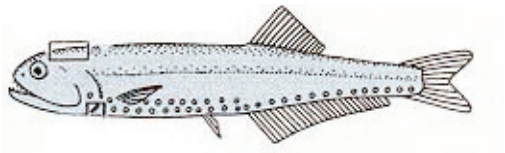
Small eye, huge mouth, no photophores on

Fish name: Bristlemouth (species #1)

Mesopelagic or bathypelagic? _____
Please explain your choice below.

Small eye, large mouth, fewer photophores than bristle mouth pictured below

Fish name: Bristlemouth (species #2)



Mesopelagic or bathypelagic? _____
Please explain your choice below.

Large eye, abundant photophores on belly, smaller mouth than bristlemouth pictured above

Graphics from *Marine Biology*. Castro, Peter and Michael E. Huber. 1992. Mosby-Year Book, Inc.